ARMY RESEARCH LABORATORY

# Improvements to the U.S. Army Research Laboratory (ARL) Army Unit Resiliency Analysis (AURA) "All Clear" Algorithm

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The Project Manager for the Corps Surface-to-Air Missile (PM CORPS SAM) is planning to use the U.S. Army Research Laboratory's (ARL) Army Unit Resiliency Analysis (AURA) model to assess the weapon system's performance. Part of the effort included a review of modifications made to AURA by PM CORPS SAM's contractor MEVATEC. This report is a result of the review of MEVATEC's "All Clear" algorithm used in determining when personnel can remove mission-oriented protective posture (MOPP) gear.

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## 1. INTRODUCTION

The Ballistic Missile Defense Organization, in its 1994 Report to Congress, noted the following:

> Currently, mature design Theater Ballistic Missiles (TBMs) are extensively deployed, and, because of their low cost and availability, they are proliferating throughout the world. . . . Adding to the threat complexity are the various warheads including high explosives, bulk or submunitions, and weapons of mass destruction (nuclear, biological, and chemical). The TBM allows the enemy, who formerly had to fly over the intended target in order to deliver their payload, to stand off at a safe range of hundreds of kilometers. Desert Storm demonstrated the difficulty of identifying an incoming TBM as a simple unitary high explosive payload or a weapon of mass destruction/casualty. An unengaged weapon of mass destruction would have far more devastating effects than even the tragic loss of life seen in the military barracks near Dhahran [Saudi Arabia]. How devastating would an engaged TBM-delivered weapon of mass destruction have been? The more relevant question to the air defense material developer is 'How lethal does my defense weapon have to be?'

Current air defense Operational Requirement Documents (ORDs) require the highest interceptor lethality possible, partly due to the current inability to reliably estimate the effects on defended assets from partially destroyed payloads, and high lethality requirements drive up interceptor complexity and cost.

To date, extensive work has been done to determine Pk contours and end game environments, etc. However, little effort has been expended to relate the defended asset dynamic effectiveness against various weapon delivery systems and payloads to the air defense system performance.

The cooperative analysis of lethality and mission effectiveness, funded by Project Manager for the Corps Surface-to-Air Missile (PM CORPS SAM), will provide a means to evaluate the defense mission effectiveness for interceptors of varying lethality, deployment strategies for assets and defense components, and engagement strategies for weapon systems.

## 2. OBJECTIVE

The objective of the PM CORPS SAM-funded work is to provide a common basis for determining the lethality requirements for the Medium Extended Air Defense System (MEADS). MEVATEC Corporation, a contractor to PM CORPS SAM, has been running the Army Unit Resiliency Analysis (AURA) program for several years. During this time MEVATEC has also been modifying source code

to address the company's specific problems. One of the portions of AURA code which MEVATEC modified was the "All Clear" algorithm. This is the algorithm that deals with the problem of vapor cloud drift and assesses when personnel can revert to their original mission-oriented protective posture (MOPP). The objective of this task was to review both the original Army Research Laboratory (ARL) algorithm and the modified MEVATEC algorithm and then to recommend any changes that ARL felt were necessary.

## 3. APPROACH

A methodology that links a force engagement simulation in a serial fashion with a lethality, atmospheric/ground transport, and unit effectiveness will be used to evaluate the dynamic effectiveness of the defended asset as a function of defense mission effectiveness. The Naval Surface Warfare Center (NSWC) Vapor, Liquid, Solid Tracking (VLSTRACK) agent transport simulation and the AURA computer simulation model, developed by ARL, and the Submunition Laydown Pattern Predictor (SLPP) propagation model will form the basis for this linkage.

## 4. SCOPE

The implementation of this methodology will require modifications to the AURA model and general support for questions that arise. MEVATEC, PM CORPS SAM's contractor, will modify the AURA code, with ARL acting as consultants.

This task involves the review of the updated "All Clear" algorithm within AURA. The AURA All Clear algorithm was modified to account for cases with large (with respect to asset size) vaporous agent clouds (i.e., primarily dosage with little or no deposition). In these cases, it was found that the original algorithm gave an unrealistically early "all clear" to come out of mission-oriented protective posture, level 4 (MOPP IV). The problem grew when effects of this shortfall were included. ARL was tasked to review the modifications made to the algorithm, assess the validity, and provide a report on the assessment with recommended changes if necessary.

5. PROBLEM

MEVATEC Corporation's modifications to the original ARL Survivability/Lethality Analysis Directorate (SLAD)/Ballistic Vulnerability/Lethality Division (BVLD) All Clear algorithm are confined to finding the largest extent of the threat cloud and then setting the XTENT variable to the greater of the two (largest extent of the unit or the largest extent of the threat cloud). The largest extent is then used to calculate TDRFT—the maximum time, in minutes, which might be required for the toxic cloud to drift across the unit. TDRFT is found by dividing XTENT by the windspeed (with units of meters per minute). XTENT has units of meters, and TDRFT has units of minutes.

The All Clear algorithm is coded in the CLDTIM.f subroutine. ARL's original version of this subroutine can be found in Appendix A, and MEVATEC's modified version of this routine can be found in Appendix B.

It needs to be noted that in MEVATEC's additions to the CLDTIM.f subroutine, where XTENT and TDRFT are calculated, a search is performed on the x and y arrays of the cloud grid Cartesian coordinates (XVPR and YVPR). The maximum and minimum corresponding x and y coordinates are determined. The Pythagorean theorem is then used to find the length of the diagonal that connects these points (XTENTV). What is important here is that these calculations are based solely on the rectangular Cartesian coordinates of the cloud grid only. During this procedure, there is no accounting for cloud values of zero within the grid. Clouds usually take on an elliptical shape as the material is transported downwind. The orientation of this elliptical shape is with the major axis following the wind direction. The elliptical cloud is characterized by a two-dimensional rectangular grid. The diagonal (XTENTV) is the distance that the opposite corners of the full rectangular grid are from one another. A good percentage of the distance may be over areas where the cloud measure value is zero and where much of the area will never be affected by the cloud.

As far as the past use of the All Clear signal when dealing with liquid agents goes, during SLAD's study of the Corps Main Command Post (CMCP) performed in FY94, the assumption was made that the minimum time for the All Clear, from liquid agent, to be declared was a minimum of 30 min plus the evaporation time of the agent (or persistence time). Doctrine calls for at least two negative testing procedures with the M8 chemical agent detection paper to have taken place. The time required to

complete a testing procedure, again according to doctrine, is 15 min, and with two sweeps required, a minimum of 30 min total was used.

## 6. SOLUTION

A better approximation for the maximum extent of a cloud which will have to transverse the unit area is simply the maximum downwind (x direction) length of the cloud. Using the diagonal not only artificially inflates this distance by using the areas of zero cloud effect, but it also seems to assume that the wind direction can vary—hence, the crosswind component used to create the diagonal. Currently, the wind direction and speed are fixed throughout the analysis. The wind speed is one of the major driving factors behind the transport and diffusion of the cloud. In the case of the cloud being larger than the asset, the only time the cloud extent is used, there are two possible cloud/unit configurations when the agent source occurs upwind of the asset:

(1) The cloud does not overlap the asset, and

(2) The cloud does overlap the asset.

When the cloud does not overlap the asset, the maximum distance that the cloud may have to travel to clear the unit is the maximum distance across the unit with respect to the wind direction (let's call this "UNITWMAX") plus the maximum of the cloud downwind length (XTENTV) and the downwind distance that the initial source of the cloud (referred to as the "start" of the cloud) is from the upwind edge of the unit (let's call this "CLDOFF").

When the cloud does overlap the asset, the maximum distance a cloud may have to travel to clear the unit is UNITWMAX plus CLDOFF.

One should realize that "large" aerosol or vapor clouds tend to be much longer than they are wide. The longest linear distance covered by the cloud can generally be found along its center line (with respect to the wind direction). If one makes the assumption that PRETOX has bounded the cloud such that the first and last x coordinates of the cloud grid are where the cloud begins and ends, one can develop an algorithm, very similar to that of MEVATEC's, to calculate the maximum extent of the cloud. The array containing the cloud measure grid needs to be accessible to the CLDTIM.f subroutine; this array is

contained in the TOXRNRM common block under the variable name VPRNR. The array containing the asset coordinates is already accessible to the CLDTIM.f subroutine; this array is contained in the CULL common block under the variable name DEPMAX. The array containing the munition impact point coordinates also needs to be accessible to the CLDTIM.f subroutine; this array is contained in the EMPLOY common block under the variable name DGZ. The wind angle variables (ANGWND, COSWND, and SINWND) are members of the WNDANG common block; this also needs to be accessible to the CLDTIM.f subroutine. Also, an assumption central to the construction of the algorithm present is that the asset center is the origin of the Cartesian coordinate system (the zero-zero point), the asset is symmetrical about the origin, and the general shape of the asset is either square or rectangular. The algorithm could be written as follows:

(1) Find the "start" of the cloud (minimum x and corresponding y). Find the y value for the maximum cloud effect value in the first x line of the cloud grid VPRNR.

(2) Find the "end" of the cloud (maximum x and corresponding y). Find the y value for the maximum cloud effect value in the last x line of the cloud grid VPRNR.

(3) Use Pythagorean's theorem and the points found in 1 and 2 to find the total extent (XTENT) of the cloud.

(4) Find the total extent of the asset with respect to the wind direction (UNITWMAX).

- Determine the angle the unit diagonal makes with the x axis (ANGDIA).
  ANGDIA = INV TAN(DEPMAX(2,2)/DEPMAX(1,2)).

- If (ANGDIA ≥ ANGWND), then UNITWMAX = 2*(DEPMAX(1,2)/COSWND).

- ELSE (ANGDIA < ANGWND) then UNITMAX = 2*(DEPMAX(2,2)/(SINWND)).

(5) Find the maximum downwind distance that the "start" of the cloud is from the upwind edge of the unit (CLDOFF). Do for all incoming rounds and pick the one which is the largest.

- X(I) is the x coordinate of the impact of round I.
- Y(I) is the y coordinate of the impact of round I.
- The downwind distance from the impact point to the asset center is DOWND. DOWND = X(I)*COSWND + Y(I)*SINWND.
- The downwind distance from the impact point to the asset edge is DOWNA. DOWNA = DOWND – (0.5*UNITMAX).
- The downwind distance from the "start" of the cloud to the edge of the asset is CLDAD. The XX(MIN) is the minimum x found in 1; this is the distance from the round function point to the "start" of the cloud (cloud ground touch down). CLDAD = DOWNA – XX(MIN).

## 7. CONCLUSION/RECOMMENDATION

A review of the updated All Clear algorithm within AURA has been completed by ARL. While the modifications made by MEVATEC were found to be valid, ARL recommends that a more robust algorithm be developed.

APPENDIX A:

ARL'S ORIGINAL CLDTIM.f SUBROUTINE

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```
      SUBROUTINE CLDTIM
C
C  THIS SUBROUTINE DEALS WITH THE PROBLEM OF VAPOR CLOUD DRIFT.
C  THE TIME REQUIRED FOR TOXIC VAPOR TO DRIFT ACROSS THE LONGEST LENGTH
C  OF THE UNIT IS CALCULATED;  TIME = LENGTH OF UNIT/VELOCITY OF WIND.
C  THIS TIME VALUE IS USED IN THE CALCULATION OF THE
C  'PERSISTENCE TIME'.  PERSISTENCE TIME IS USED HERE TO REFER
C  TO THE LENGTH OF TIME THAT A TOXIC HAZARD REMAINS IN THE UNIT
C  AREA. PERSONNEL DO NO REVERT TO ORIGINAL MOPP POSTURE
C  UNTIL SOME TIME AFTER THE 'PERSISTENCE' TIME HAS ELAPSED.
C
      COMMON/CULL/LCULL(2),DEPMAX(2,2),DELMAX(@NWP),TLEMAX
      COMMON/IO/ IM5,IM6
      COMMON/LTHTYP/ LCNV, LNUKE, LNUCDN, LTOX, LTOXDN, LNUCDS, LTOXDS,
c smart
     + LSMART
      LOGICAL LTOX
      COMMON/RECOOP/ NRECT, TIMGAP, TRECUP(@TIM), TRECON(@TIM)
      COMMON/TALLY/ NREC,TALTIM(@TIM),LNKWKT(@TIM),LCHNST(@TIM),
     + EFFREC(@TIM)
      COMMON/TOXTRM/XTRC(@TW,2),YTRC(@TW,2),XTRP(@TW,2,2),YTRP(@TW,2,2),
     + XTRV(@TW,2,2),YTRV(@TW,2,2),CTMIN(@TW),CTMAX(@TW),TOXWND(@TW),
     + CNCXT(@TW),CNCX(@TW),CNCY(@TW),CNCTP(@TW)
      COMMON/TXCLTH/NTXWPN,NXCNTM(@TW),NTVPR(@TW),NXVPR(@TW),NYVPR(@TW),
     + NDXTX(@TW,4),XCNTM(@TW,@XTC),TVPR(@TW,10),XVPR(@TW,@XTW),
     + YVPR(@TW,@YTW),EVPTMX(@TW),PRSTIM(@TW),NYCNTM(@TW),
     + YCNTM(@TW,@YTW)
C
C  DETERMINE THE DRIFT TIME OF THE TOXIC CLOUD
C  AND ADD THIS TO THE PERSISTENCE TIME GIVEN BY NUSSE(TIME FOR
C  AVERAGE DROPLET TO EVAPORATE.)
C
C  TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT IS CALCULATED BASED ON
C  THE RELATIONSHIP: DISTANCE = VELOCITY * TIME.
C  TDRFT =  MAXIMUM LENGTH OF UNIT/VELOCITY OF WIND.
C  TDRFT IS TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT.
C
C  LTOX IS LOGICAL SIGNIFYING WHETHER OR NOT THIS IS A TOXIC SCENARIO.
C  IF THIS IS A TOXIC SCENARIO THEN DO THE FOLLOWING CALCULATION:
C
      IF( LTOX )  THEN
C
C  CALCULATE MAXIMUM LENGTH OF THE UNIT BASED ON PYTHAGOREAN THEOREOM.
C  DEPMAX IS ARRAY OF MAXIMA AND MINIMA DEPLOYMENT POINTS.
C  DEPMAX(1,2) IS THE MAXIMUM VALUE DEPLOYMENT POINT ALONG X AXIS.
C  DEPMAX(1,1) IS THE MINIMUM VALUE ALONG THE X AXIS.
C  DEPMAX(2,2) IS THE MAXIMUM VALUE ALONG THE Y AXIS.
C  DEPMAX(2,1) IS THE MINIMUM VALUE ALONG THE Y AXIS.
C
C  XTENT IS THE LARGEST EXTENT OF THE UNIT ACROSS WHICH
C  A TOXIC CLOUD MIGHT TRAVEL
C
         XTENT = SQRT( (DEPMAX(1,2)-DEPMAX(1,1))**2 +
     +     (DEPMAX(2,2)-DEPMAX(2,1))**2 )
C
         DO 24  K = 1, @TW
         IF( TOXWND(K) .GT. 0.01 )  THEN
C
C  MULTIPLY TOXWIND BY 60 TO CONVERT FROM SECONDS TO MINUTES.
C  MINUTES = METERS/[(METERS/SECOND)(60 SECONDS/MINUTE)].
C
            TDRFT = XTENT / ( TOXWND(K)*60. )
C
C  IF WIND SPEED IS CLOSE TO ZERO, THEN THERE IS NO DRIFT DOWNWIND,
C  SO TDRFT IS SET CLOSE TO INFINITE.  CLOUD WON'T DRIFT DOWNWIND
C  AND PERSONNEL WILL BE FORCED TO STAY IN MOPP UNTIL EVAPORATION
C  OF AGENT.  THIS IS VALID FOR THE PERSISTENT AGENT CASE, BUT
C  NOT FOR A NONPERSISTENT AGENT.  A CHECK AND CORRECTION IS
C  MADE FOR THIS LATER.
C
         ELSE
```

```
                TDRFT = 1.E35
             ENDIF
C
C  TDRFT IS THE TIME - IN MINUTES - TO DRIFT ACROSS THE
C  LARGEST EXTENT OF THE UNIT.
C
C  PRSTIM CONTAINS THE TIME OF THE FIRST DOSAGE GRID TO
C  SHOW NO INCREASES.  FOR A PURE LIQUID (NO VAPOR) IT IS 0.
C  IF EVERY GRID SHOWED AN INCREASE, IT IS 1.E35. (THE
C  AURA ANALYST MUST BE CAREFUL WHEN CHOOSING NUSSE INPUT
C  TIMES TO AVOID MODELING AN 'INFINETELY' PERSISTENT
C  HAZARD AS A RESULT OF SELECTING TIMES WHICH ARE
C  NOT REPRESENTATIVE OF THE LIFETIME OF THE HAZARD.
C
C  TOTAL PERSISTENCE TIME IS ESTIMATED BY TAKING THIS
C  MAXIMUM EVAPORATION TIME AND ADDING THE DRIFT TIME TO IT
C  TO ACCOUNT FOR THE SECONDARY EVAPORATION HAZARD OF LIQUID
C  AGENT.  HOWEVER, THERE IS NO SECONDARY VAPOR HAZARD FOR PURELY
C  VAPOR AGENTS.
C
C  TO CALCULATE TOTAL PERSISTENCE TIME....
C
C  FOR A LIQUID AGENT:
C  ADD EVPTMX, THE EVAPORATION TIME OF A LIQUID AGENT,
C  TO THE DRIFT TIME TO DETERMINE THE LENGTH OF TIME A
C  HAZARD REMAINS IN THE UNIT AREA.
C
             PRSTIM(K) = EVPTMX(K)+TDRFT
C
C  FOR A VAPOR AGENT:  CHECK AGAINST THE POSSIBILITY OF ZERO WIND.
C  IF ZERO WIND, THE MAXIMUM PERSISTENCE TIME IS THE MAXIMUM
C  NUSSE GRID TIME, TVPR. NTVPR IS THE NUMBER OF TOXIC VAPOR
C  WEAPONS.  SET QQQ TO THE MAXIMUM OF THE NUSSE
C  GRID TIME OR THE EVAPORATION TIME OF A LIQUID AGENT(0 IF
C  VAPOR AGENT).
C
             IF ( NTVPR(K) .GT. 0 ) THEN
         QQQ = AMAX1(EVPTMX(K),TVPR(K,NTVPR(K)))
             ELSE
         QQQ = EVPTMX(K)
             ENDIF
C
C  SINCE BOTH PRSTIM AND QQQ ARE UPPER BOUNDS,
C  CHOOSE THE LESSER OF THE TWO.  THIS PREVENTS THE
C  UNIT FROM STAYING IN MOPP AN INFINITE AMOUNT OF TIME
C  AFTER A NONPERSISTENT AGENT ATTACK.
C
             PRSTIM(K) = AMIN1(PRSTIM(K),QQQ)
C
C  FINALLY, WARN USER IF PERSISTENCE TIME EXCEEDS ENCOUNTER LENGTH.
C  TALTIM IS AN ARRAY OF RECONSTITUTION TIMES.
C  NRECT IS NUMBER OF RECONSTITUTION TIMES.
C
             IF( PRSTIM(K) .GT. TALTIM(NRECT) )  THEN
                WRITE(IM6,69) PRSTIM(K),K,TALTIM(NRECT)
   69           FORMAT(' *** WARNING ***  PERSISTENCE TIME (',F10.2,
     +          ') OF TOXIC WEAPON DISPERSION # ',I4,' IS LONGER THAN',
     +          ' ENCOUNTER TIME (',F10.2,')',/
     +          ' ONCE INTO MOPP, PERSONNEL WILL NOT GET OUT.' )
                WRITE(1,69) PRSTIM(K),K,TALTIM(NRECT)
             ENDIF
   24        CONTINUE
          ENDIF
          RETURN
          END
```

APPENDIX B:

MEVATEC'S CLDTIM.f SUBROUTINE

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```
      SUBROUTINE CLDTIM
C
C  THIS SUBROUTINE DEALS WITH THE PROBLEM OF VAPOR CLOUD DRIFT.
C  THE TIME REQUIRED FOR TOXIC VAPOR TO DRIFT ACROSS THE LONGEST LENGTH
C  OF THE UNIT IS CALCULATED;  TIME = LENGTH OF UNIT/VELOCITY OF WIND.
C  THIS TIME VALUE IS USED IN THE CALCULATION OF THE
C  'PERSISTENCE TIME'.  PERSISTENCE TIME IS USED HERE TO REFER
C  TO THE LENGTH OF TIME THAT A TOXIC HAZARD REMAINS IN THE UNIT
C  AREA. PERSONNEL DO NO REVERT TO ORIGINAL MOPP POSTURE
C  UNTIL SOME TIME AFTER THE 'PERSISTENCE' TIME HAS ELAPSED.
C
      COMMON/CULL/LCULL(2),DEPMAX(2,2),DELMAX(50),TLEMAX
      COMMON/IO/ IM5,IM6
      COMMON/LTHTYP/ LCNV, LNUKE, LNUCDN, LTOX, LTOXDN, LNUCDS, LTOXDS
      LOGICAL LTOX
      COMMON/RECOOP/ NRECT, TIMGAP, TRECUP(20), TRECON(20)
      COMMON/TALLY/ NREC,TALTIM(20),LNKWKT(20),LCHNST(20),
     + EFFREC(20)
      COMMON/TOXTRM/XTRC(13,2),YTRC(13,2),XTRP(13,2,2),YTRP(13,2,2),
     + XTRV(13,2,2),YTRV(13,2,2),CTMIN(13),CTMAX(13),TOXWND(13),
     + CNCXT(13),CNCX(13),CNCY(13),CNCTP(13)
      COMMON/TXCLTH/NTXWPN,NXCNTM(13),NTVPR(13),NXVPR(13),NYVPR(13),
     + NDXTX(13,4),XCNTM(13,176),TVPR(13,10),XVPR(13,300),
     + YVPR(13,99),EVPTMX(13),PRSTIM(13),NYCNTM(13),
     + YCNTM(13,50)
C
C  DETERMINE THE DRIFT TIME OF THE TOXIC CLOUD
C  AND ADD THIS TO THE PERSISTENCE TIME GIVEN BY NUSSE(TIME FOR
C  AVERAGE DROPLET TO EVAPORATE.)
C
C  TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT IS CALCULATED BASED ON
C  THE RELATIONSHIP: DISTANCE = VELOCITY * TIME.
C  TDRFT =  MAXIMUM LENGTH OF UNIT/VELOCITY OF WIND.
C  TDRFT IS TIME FOR CLOUD TO DRIFT DOWNWIND OF UNIT.
C
C  LTOX IS LOGICAL SIGNIFYING WHETHER OR NOT THIS IS A TOXIC SCENARIO.
C  IF THIS IS A TOXIC SCENARIO THEN DO THE FOLLOWING CALCULATION:
C
      IF( LTOX )  THEN
C
C  CALCULATE MAXIMUM LENGTH OF THE UNIT BASED ON PYTHAGOREAN THEOREOM.
C  DEPMAX IS ARRAY OF MAXIMA AND MINIMA DEPLOYMENT POINTS.
C  DEPMAX(1,2) IS THE MAXIMUM VALUE DEPLOYMENT POINT ALONG X AXIS.
C  DEPMAX(1,1) IS THE MINIMUM VALUE ALONG THE X AXIS.
C  DEPMAX(2,2) IS THE MAXIMUM VALUE ALONG THE Y AXIS.
C  DEPMAX(2,1) IS THE MINIMUM VALUE ALONG THE Y AXIS.
C
C  XTENTV IS THE LARGEST EXTENT OF THE CLOUD

      XMIN = 1.0E10
      XMAX = -1.0E10
      YMIN = 1.0E10
      YMAX = -1.0E10

      DO 995 K = 1,13
      DO 996 J = 1,NXVPR(K)
       XMIN = AMIN1(XMIN,XVPR(K,J))
       XMAX = AMAX1(XMAX,XVPR(K,J))
996   CONTINUE
      DO 995 J = 1,NYVPR(K)
       YMIN = AMIN1(YMIN,YVPR(K,J))
       YMAX = AMAX1(YMAX,YVPR(K,J))
995   CONTINUE
       XTENTV = SQRT((XMAX - XMIN)**2 +
     +                (YMAX - YMIN)**2 )

C  XTENT IS THE LARGEST EXTENT OF THE UNIT ACROSS WHICH
C  A TOXIC CLOUD MIGHT TRAVEL
C
        XTENT = SQRT( (DEPMAX(1,2)-DEPMAX(1,1))**2 +
     +    (DEPMAX(2,2)-DEPMAX(2,1))**2 )
```

```
C   XTENT IS THE GREATER OF THE DIAGONAL OF THE CLOUD VERSUS
C        THE DIAGONAL OF THE UNIT

         XTENT = AMAX1(XTENT,XTENTV)
C
          DO 24  K = 1, 13
          IF( TOXWND(K) .GT. 0.01 )  THEN
C
C  MULTIPLY TOXWIND BY 60 TO CONVERT FROM SECONDS TO MINUTES.
C  MINUTES = METERS/[(METERS/SECOND)(60 SECONDS/MINUTE)].
C
             TDRFT = XTENT / ( TOXWND(K)*60. )
C
C  IF WIND SPEED IS CLOSE TO ZERO, THEN THERE IS NO DRIFT DOWNWIND,
C  SO TDRFT IS SET CLOSE TO INFINITE.  CLOUD WON'T DRIFT DOWNWIND
C  AND PERSONNEL WILL BE FORCED TO STAY IN MOPP UNTIL EVAPORATION
C  OF AGENT.  THIS IS VALID FOR THE PERSISTENT AGENT CASE, BUT
C  NOT FOR A NONPERSISTENT AGENT.  A CHECK AND CORRECTION IS
C  MADE FOR THIS LATER.
C
          ELSE
             TDRFT = 1.E35
          ENDIF
C
C  TDRFT IS THE TIME - IN MINUTES - TO DRIFT ACROSS THE
C  LARGEST EXTENT OF THE UNIT.
C
C  PRSTIM CONTAINS THE TIME OF THE FIRST DOSAGE GRID TO
C  SHOW NO INCREASES.  FOR A PURE LIQUID (NO VAPOR) IT IS 0.
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C  TO ACCOUNT FOR THE SECONDARY EVAPORATION HAZARD OF LIQUID
C  AGENT.  HOWEVER, THERE IS NO SECONDARY VAPOR HAZARD FOR PURELY
C  VAPOR AGENTS.
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C  TO CALCULATE TOTAL PERSISTENCE TIME....
C
C  FOR A LIQUID AGENT:
C  ADD EVPTMX, THE EVAPORATION TIME OF A LIQUID AGENT,
C  TO THE DRIFT TIME TO DETERMINE THE LENGTH OF TIME A
C  HAZARD REMAINS IN THE UNIT AREA.
C
          PRSTIM(K) = EVPTMX(K)+TDRFT
C
C  FOR A VAPOR AGENT:  CHECK AGAINST THE POSSIBILITY OF ZERO WIND.
C  IF ZERO WIND, THE MAXIMUM PERSISTENCE TIME IS THE MAXIMUM
C  NUSSE GRID TIME, TVPR. NTVPR IS THE NUMBER OF TOXIC VAPOR
C  WEAPONS.  SET QQQ TO THE MAXIMUM OF THE NUSSE
C  GRID TIME OR THE EVAPORATION TIME OF A LIQUID AGENT(0 IF
C  VAPOR AGENT).
C
          IF ( NTVPR(K) .GT. 0 ) THEN
      QQQ = AMAX1(EVPTMX(K),TVPR(K,NTVPR(K)))
          ELSE
      QQQ = EVPTMX(K)
          ENDIF
C
C  SINCE BOTH PRSTIM AND QQQ ARE UPPER BOUNDS,
C  CHOOSE THE LESSER OF THE TWO.  THIS PREVENTS THE
C  UNIT FROM STAYING IN MOPP AN INFINITE AMOUNT OF TIME
C  AFTER A NONPERSISTENT AGENT ATTACK.
C
          PRSTIM(K) = AMIN1(PRSTIM(K),QQQ)
C
C  FINALLY, WARN USER IF PERSISTENCE TIME EXCEEDS ENCOUNTER LENGTH.
```

```
C  TALTIM IS AN ARRAY OF RECONSTITUTION TIMES.
C  NRECT IS NUMBER OF RECONSTITUTION TIMES.
C
            IF( PRSTIM(K) .GT. TALTIM(NRECT) )  THEN
               WRITE(IM6,69) PRSTIM(K),K,TALTIM(NRECT)
   69          FORMAT('0*** WARNING ***  PERSISTENCE TIME (',F10.2,
     +         ') OF TOXIC WEAPON DISPERSION # ',I4,' IS LONGER THAN',
     +         ' ENCOUNTER TIME (',F10.2,')',/
     +         ' ONCE INTO MOPP, PERSONNEL WILL NOT GET OUT.' )
               WRITE(1,69) PRSTIM(K),K,TALTIM(NRECT)
            ENDIF
   24       CONTINUE
         ENDIF
         RETURN
         END
```

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